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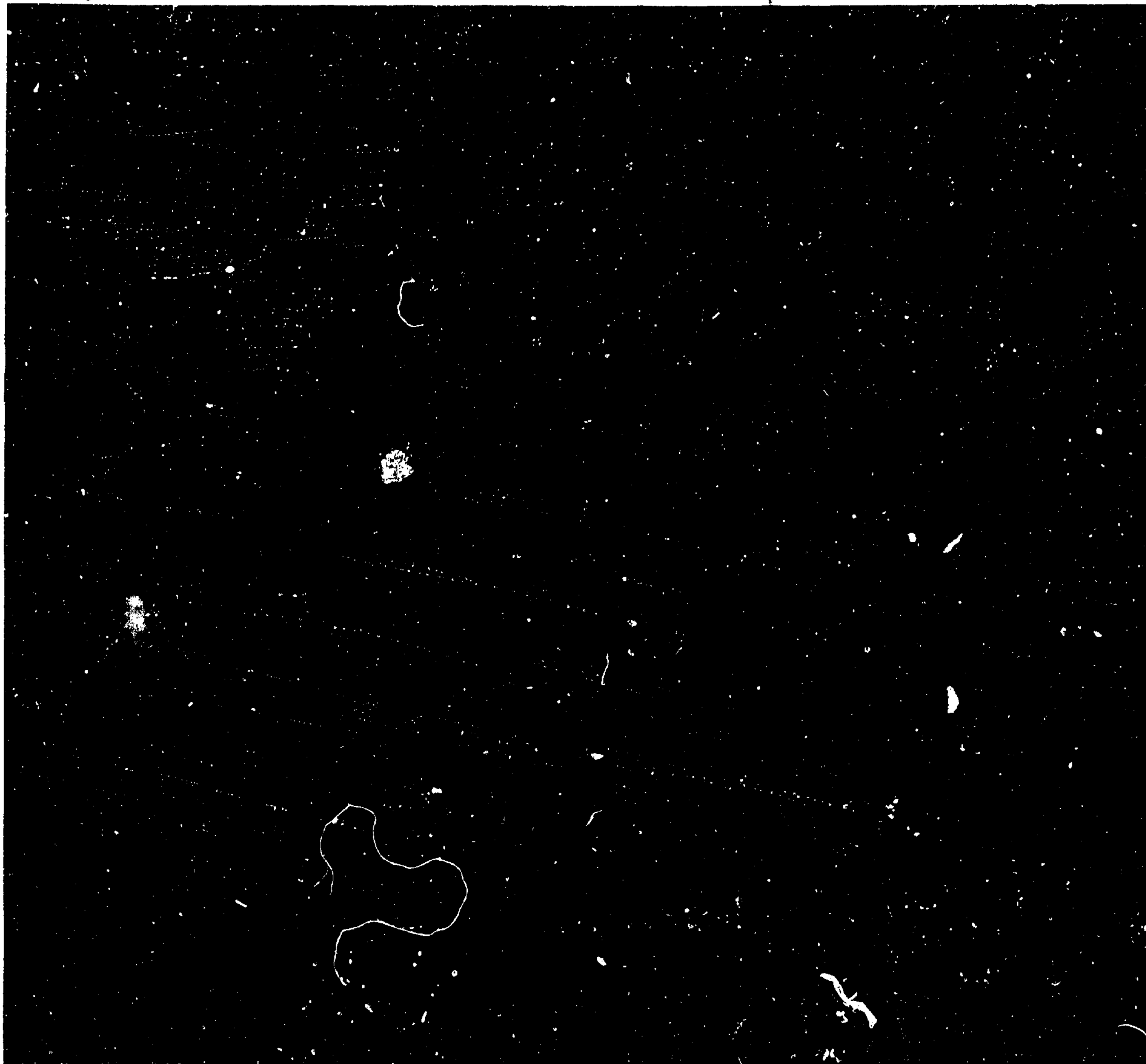

MAYAGUEZ , PUERTO RICO
00708

SPECIAL REPORT
to
OFFICE OF NAVAL RESEARCH
OCEANIC BIOLOGY PROGRAMS
on

THE OCEAN EAGLE OIL SPILL

by

M. J. Cerame-Vivas

This work was partly supported by
Contract N 00014-67-C-0282
to M. J. Cerame-Vivas, Director
Department of Marine Science
University of Puerto Rico
Mayaguez, Puerto Rico 00708

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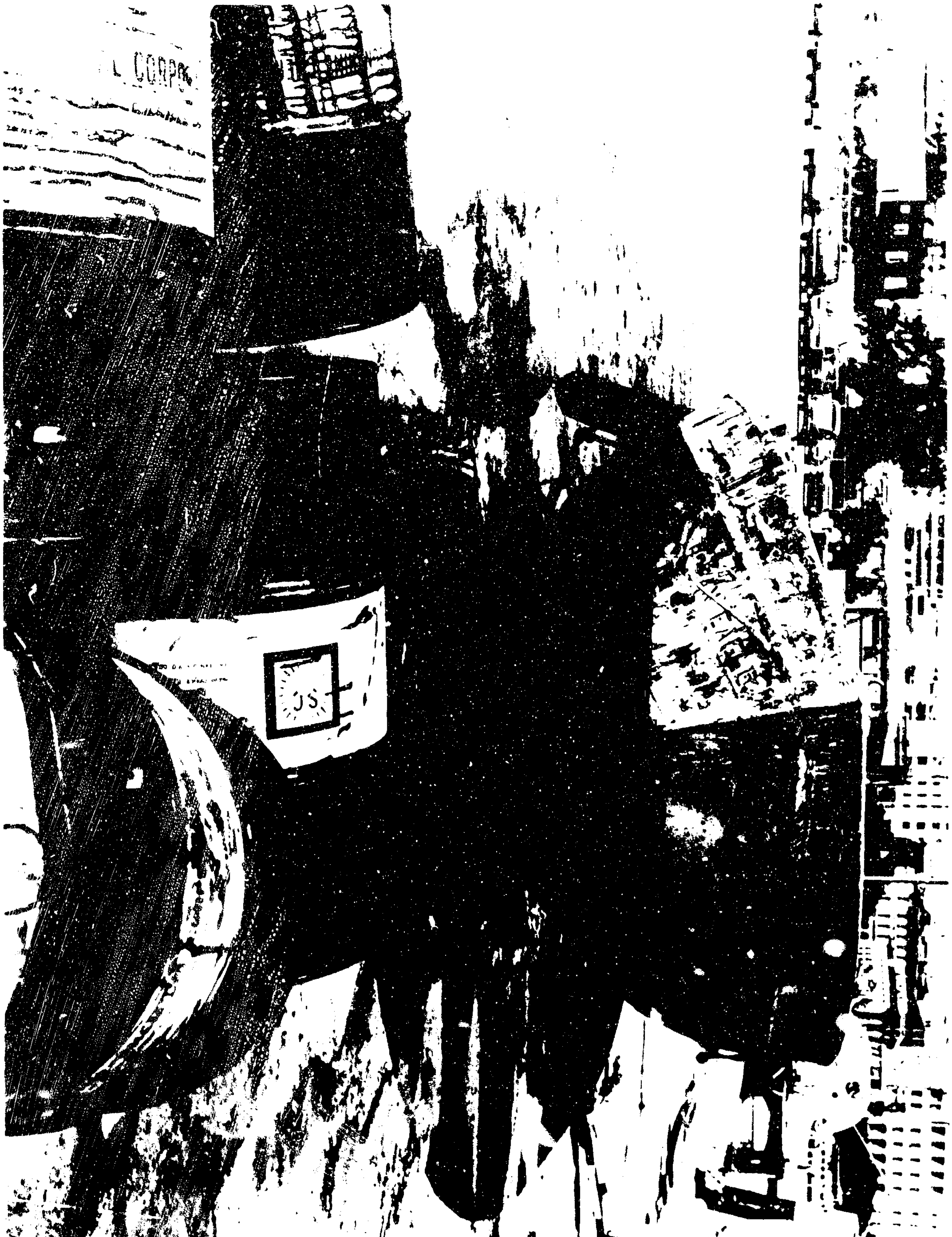


Lifeboat of the stricken Liberian Tanker OCEAN EAGLE at the U.S. Coast Guard Base in San Juan, Puerto Rico, March, 1968.

Summary

During March 4 to March 21, 1968, personnel and facilities of the Department of Marine Sciences, University of Puerto Rico, Mayaguez, moved to San Juan to work on the OCEAN EAGLE oil spill and to advise the Government of the Commonwealth of Puerto Rico as such advice was needed. The deployment of Marine Sciences' staff and facilities in San Juan included resources pertinent to ONR Contract N 00014-67-C-0282, Biogeography of the Benthos of Puerto Rico and the Virgin Islands.

The activities of the Marine Sciences group in San Juan included, 1) a survey of littoral forms affected by the spill, 2) a survey of inshore fishes affected by the spill, 3) detergent toxicities on littoral and sub-littoral invertebrates, 4) detergent toxicities on inshore fishes, 5) oil adsorbancy tests on a number of substances, and 6) toxicity tests of the absorbants.

Day-by-Day Report

Sunday, March 3: The tanker OCEAN EAGLE ran aground at the entrance to San Juan Harbor in the early hours of the morning and shortly afterwards broke in two. The oil spread in the harbor, extended westward towards Punta Salinas and eastward towards the Condado section.

Monday, March 4: An overflight was made in a Grand Commander by the Marine Sciences group to observe full extent of the spill. A rip-current was keeping the oil away from the western beaches of Ensenada Boca Vieja. Eastward, beaches were affected as far as Punta en Medio, off the International Airport. The Marine Sciences group met with Secretary of Public Works Francisco Lizardi and with Federal Water Pollution Control Administration officials from Cincinatti, Washington D.C., and Atlanta.

Oil was still leaking from the hulks and moving eastward because of the storm swells partly responsible for the disaster. Normal coastal currents being to the west along the north and south coasts of Puerto Rico, major cleanups at this point would be futile until normal coastal current patterns were reestablished. Both popular and government pressures, however, demanded immediate action. Navy and Coast Guard detachments tried in vain to tow away the hulks.

Tuesday, March 5: The Marine Sciences group organized as a task force and assigned shifts among staff and graduate students. The Parguera and the San Juan components were designated.

Wednesday, March 6: A mobile laboratory was constructed over a trailer platform. An advance group went to San Juan to chose site for mobile laboratory and to make lodging arrangements for personnel to follow.

Thursday, March 7: Mobile laboratory was sited in San Juan. Clean sea water and bioassay specimens brought in. Batteries of tanks and aquaria were arranged. Detergent samples procured. Toxicity studies on oil and detergents were begun both on fish and on invertebrates.

Friday, March 8: Twenty-four hour toxicity tests were completed. Other tests continued. Observations on detergent-treated beaches showed beaches were turning into quicksand. Press conference. Meeting with government officials to determine course of action to follow. Order was issued to discontinue detergents. Tests on adsorbents were begun.

Saturday, March 9: Adsorbency tests were continued. Toxicity tests on adsorbents continued.

Sunday, March 10: The Secretary of Public Works visited our mobile laboratory to obtain results on adsorbent tests. With the results and some of the experiments still before him, he ordered Ekoperl flown into Puerto Rico. Research vessel CARITE was made available to Public Works for spreading the adsorbent.

Monday, March 11: Overflights to determine best deployment of dust. CARITE deployed absorbent.

Tuesday, March 12: CARITE deployed adsorbent.

Wednesday, March 13: CARITE continued to deploy adsorbent. A scientist who was on board had to be taken to the hospital for treatment for adsorbent dust in his eye. The shores were surveyed for damage to littoral species. In the shores surveyed, damage was total.

Thursday, March 14: Mobile laboratory is towed back to Mayaguez. CARITE continues to spread adsorbent.

Thursday, March 21: CARITE returned to Mayaguez.

Survey of Littoral Species

Damage to littoral species between Isla de Cabras, to the west, and the Condado Section, to the east of San Juan Harbor Inlet (Boca del Morro) was complete (Fig. 1). Sessile and slow-moving forms were covered with oil and killed. Molluscs such as chitons and limpets not affected by the oil itself were harmed either by the emulsified oil-and-detergent mixture or by the detergents, where the most notable effect was that the molluscs were unable to adhere to their substrate. Limpets and chitons were washed off the rocks by the waves and either died or were preyed upon by sturdier forms.

Along wharves, docks, and pilings, barnacles and algae were obliterated. Motile crustaceans such as the isopod Ligyda faired safe above the oil, but got stuck and died in the oil-impregnated zone. All beach organisms in the affected zones were harmed (Fig. 2).

Recovery of the littoral zone has been relatively fast, as expressed by the following letter:

FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
5555 Ridge Avenue, Cincinnati, Ohio 45213

COPY

Alec Little
Southeast Water Laboratory
FWPCA, USDI, Athens, Ga.

July 17, 1968

THRU: K. M. Mackenthun, Acting Chief, B & C Sec., TA & I Br.

R Keith Stewart, Aquatic Biologist
Biological & Chemical Section, TA & I Branch

Existing Status of Oil Pollution in San Juan Harbor, Puerto Rico, as caused by the Liberian Oil Tanker, "Ocean Eagle," March 3, 1968.

As per your request to Mr. Kenneth M. Mackenthun through Mr. A. D. Sidio, selected reaches of San Juan Harbor were investigated on July 13, 1968, to ascertain any existing effects of the oil spillage as caused by the tanker, Ocean Eagle, on March 3, 1968, at the mouth of San Juan Harbor. Only shoreline reaches were investigated: boats and other equipment could not be arranged because of time commitments. The shoreline reaches surveyed consist of:

1. Puente de la Constitución (Kennedy Bridge)
2. Bahía de Puerto Nuevo (Central Termo Eléctrica)
3. Northern Sector of Cataño
4. Eastern Sector of Isla de Cabras
5. Palo Seco
6. Southeastern Sector of Ensenada Boca Vieja

Intertidal aquatic life was well recovered from the conditions prevalent in the harbor shortly after the oil spill; i.e. March 3-9, 1968, and there was no evidence of oil or oily residues in these intertidal areas.

Hardened oily residues were observed on pier and bridge structures as well as other harbor facilities and rocky beaches above the mean highwater mark. Recovery by aquatic life in the intertidal reaches and immediate sublittoral areas (just under the wave action) was not complete. For example, fiddler crabs (Uca pugnax) were observed in abundance in area 1 above, but certain other fauna appeared to be lacking except for dense diatom populations on mud flats in the associated vicinity.

Also observed were small populations of five species of littorine animals in a rocky shoreline area, Item 4 above. Such animals consisted of the following:

Littorina ziczac
Nerite versicolor
Nerite tesselata
Chiton squamosa
Acanthopleura granulata

Each of the preceding animals were found in small numbers. The lack of other kinds of sublittoral organisms such as the antillean urchin, Diadema antillensis, and/or the red-black urchin, Echinometra lucunter as well as certain snails (Tectarius muricatus and Nodilittorina in the high supralittoral and Purpura patula and Astraea caelata or Astraea tuber in littoral zones) is suggestive that recovery was incomplete. Much attached algae (Ulva sp.) was noted near the same vicinity and near Cataño. The lack of oil in sandy beaches was quite apparent and swimmers were noted in such areas.

In brief, several observations were made in what are judged to be critical areas of San Juan Harbor; these disclosed that recovery by aquatic life from the oil contamination caused by the Ocean Eagle has been very excellent, but not quite complete. It would not appear necessary at this time to make additional studies in San Juan Harbor relevant to the oil spill in March, 1968.

cc: A. D. Sidio
K. M. Mackenthun
L. E. Keup
N. A. Thomas
L. P Parrish
Dr. Cerame-Vivas, University of P.R.
Mayaguez. Puerto Rico

RKS:rk

Field Observations on Fishes
(By William Eger)

1. On March 12, 9 days after the grounding of the Ocean Eagle, a two hour survey by small boat was made of part of San Juan Bay. The area covered extended along the shoreline from the San Antonio Channel south around Isla Grande to the J. F. Kennedy bridge; then west and north to Punta Cataño. During this period the following fishes were found dead:

15 Opisthonema oglinum - arenque, sardina
7 Trichiurus lepturus - machete
6 Gobioides braussonneti - gobido
2 Cetengraulis sp. - anchoa
1 Sphyraena barracuda - picúa brava
1 Polydactylus virginicus - barbudo
1 Mugil curema - jarea
1 Chloroscombrus chrysurus - casabe

In addition, during this same period, the following fish were observed in a state of stress:

Sardinella anchovia - sardina, cascarúa
Strongylura sp. - agujón

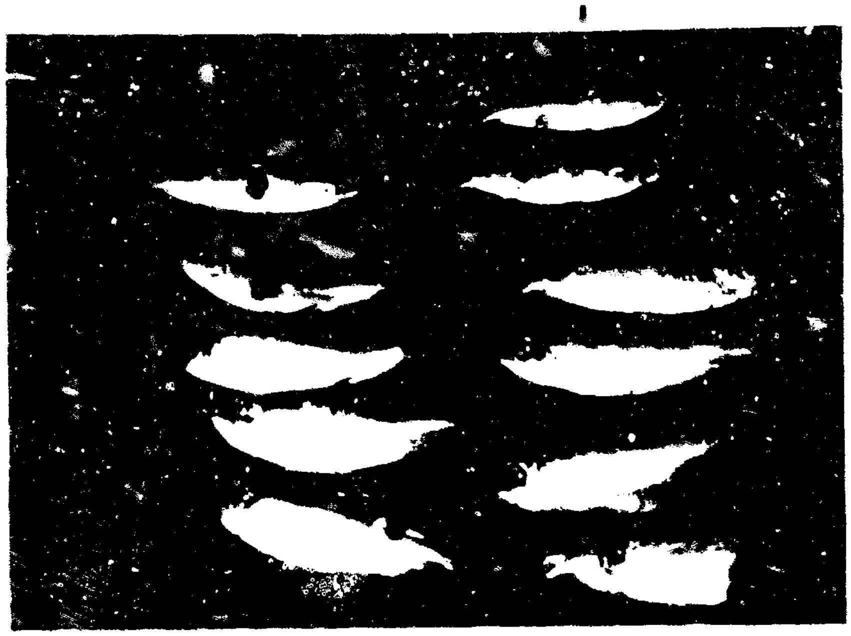
A few small schools of live Opisthonema oglinum were observed. Several fish in the appeared to show evidence of lesions on the dorsum resulting in patches where the tissue underlying the skin could be seen. There were a greater number of fish of this species seen. There were a greater number of fish of this species seen under the puente G. Esteves in the San Antonio Channel. The water here was relatively clear compared to the rest of San Juan Bay; probably because there is a good exchange of clearer water coming in from the NE via de Balneario Condado.

2. On March 22, 19 days after the grounding of the Ocean Eagle I observed very large schools of Opisthonema oglinum among the docks of the Club Náutico. The number of fish present was estimated to have been over 100,000. Based on photographs and sampling of the population, it is estimated that there was at least a 95% incidence of fish with abnormal lesions. The fish were in varying stages of stress, with many of them showing abnormal swimming behavior, loss of balance, and death. Examination of these fishes showed that some of the lesions had progressed to such an extent that the vertebrae, ribs or viscera were exposed. The internal anatomy revealed a general deterioration of tissue. A small percent (less than 5%) of those fish infected, showed some signs of healing and regeneration of tissue around the lesions.

At the present time, the causative agent responsible for these gross lesions is not knwon. Possibilities being considered at present are:

1. Effect by a toxic component of oil from the Ocean Eagle.
2. Effect by a toxic component of one or more detergents used in clean-up operations during the Ocean Eagle disaster.
3. Effect caused by a fungus or bacteria. It is possible that a component from either the oil or one or more detergents caused a disruption of natural protective skin mucus lining or scales, thereby allowing infection to spread to the underlying tissues. This problem is presently being examined. This fish of particular concern because it is the prime bait fish used by fishermen in the area.

3. The ten species of fish observed to have been either killed or adversely affected, probably due to the Ocean Eagle disaster, undoubtedly represent only a fraction of the total fish that ultimately were damaged. Of these ten species, nine are of direct commercial importance.



Ophistonema oglinum showing lesions observed in 95% of the population during the Ocean Eagle disaster. These specimens were collected in San Antonio Channel, near the Club Nautico.

Detergent Toxicities on Invertebrates

Bioassays on the sea-urchins Diadema antillarum, Tripneustes esculentus, and Echinometra lucunter were made of emulsifiers such as Polycomplex A-11, Jansolov 60, Hemco #2, and Muratti. Specimens were brought in from Point Vacia Talega, east of San Juan and free from oil at this time. Clean sea water was also obtained there and transported to the laboratory in 20-gallon covered plastic buckets.

Batteries of smaller buckets were arranged with 5 L of clean sea water in each and each with aereation through a diffusion stone. A specimen of each species of echinoid was placed in each bucket. Care was taken to have members of the same species be of equivalent sizes. No attempt was made at sexing the urchins.

Detergents were added in a series of the buckets to bring detergent concentrations to the following levels

#1	1 part per thousand detergent
#2	0.1 "
#3	0.01 "
#4	0.001 "
#5	0.0001 "
#6	Clean sea water, no detergent

All the buckets were observed every hour. The criterion for death of the echinoids was the lack of movement of spines and tube feet.

Results - Diadema antillarum

#1: 1 ppt

Immediate loss of pigment. Erratic movement of the spines. Death in 15 minutes.

#2: 0.1 ppt

Marked loss of pigment. Loss of spine molility in 40 minutes. Death in 2 hrs and 55 minutes.

#3: 0.01 ppt

Marked loss of pigment. Loss of spine movement within the first hour of exposure. Feeble tube feet movement throughout 24 hrs. of observations.

#4: 0.001 ppt

Loss of pigment, though not enough to stain the water as in all of the above tests. Loss of spine movement in 6 hrs. Feeble tube feet movements throughout remaining 18 hrs. of observations.

#5: 0.0001 ppt

Slight loss of pigment. Some loss of spine movement during first 6 hrs. Feeble tube feet movement throughout 24 hrs.

#6: Control. Clean sea water.

Diadema normal and motile throughout experiment.

Tripneustes esculentus

#1: 1 ppt

Stiffening of spines during first 50 minutes. Afterwards unable to hold spines perpendicular to test. Death in 1 hr and 35 min.

#2: 0.1 ppt

Stiffening of spines during first hour. No change until death after 8 hrs and 45 minutes of exposure.

#3: 0.01 ppt

Shed gametes in 45 min. Stiffening of spines during first hour of exposure. No further change during experiment.

#4: 0.001 ppt

Stiffening of spines during first two hours of exposure. No further change during experiment.

#5: 0.0001 ppt

Partial stiffening of spines. No further change during experiment.

#6: Control. Clean sea water

Tripneustes normal and motile throughout experiment.

Echinometra lucunter

#1: 1 ppt

Stiffening of spines in 30 minutes. Rigidity of spines in 50 minutes. Death 1 hr and 50 min. after exposure.

#2: 0.1 ppt

Spinal disorientation in 1 hr and 15 minutes. Death after 5 hrs.

#3: 0.01 ppt

Stiffening of spines during 1st hour. Condition unchanged throughout experiment.

#4: 0.001 ppt

Same as above

#5: 0.0001 ppt

Same as above

#6: Control. Clean sea water.

Echinometra normal and motile throughout experiments.

Conlcusions

The emergency conditions and the promptness with which we needed information during the disaster did not allow us to extend the bioassays to the more usual 72-hour period. It was felt, however, that as far as detergent concentrations greater than 0.001 ppt was concerned, our results had shown that the detergents were toxic to some littoral species. In spite of our time limitations, and in spite of the small experimental population used, we felt that the information obtained justified our recommendations to discontinue the use of detergents.

Detergent Toxicities on Fishes
(By William Eger)

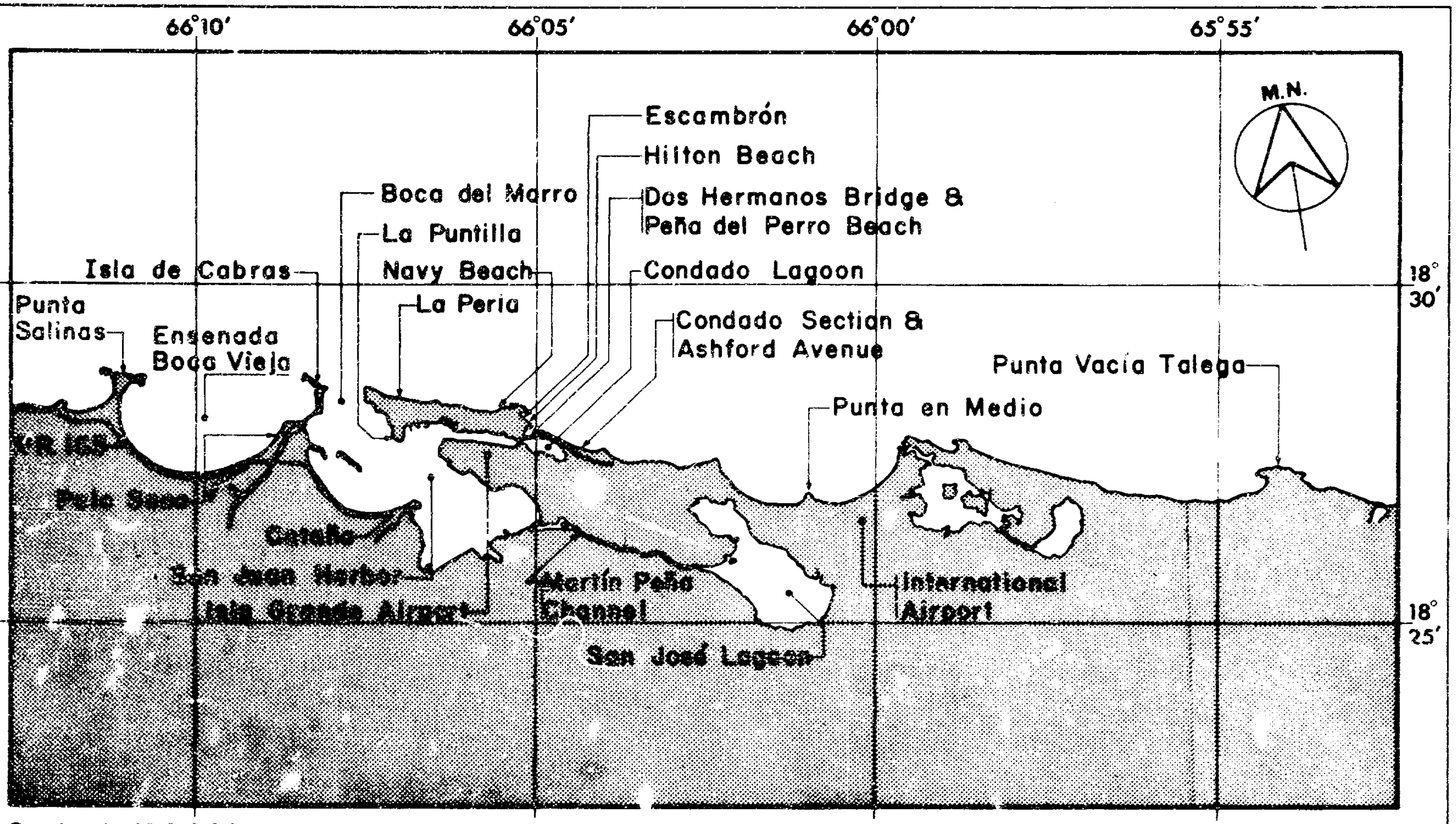
Considerations

Because of the immediate need for preliminary results on which to base intelligent counsel, these experiments were generally not conducted for more than 18 hours for any one test, except where indicated. All tests, except one (the 27 ppm series) were conducted at the Dept. of Marine Sciences temporary mobile laboratory in Condado. The 27 ppm (parts per million) series was conducted at the Dept. of Marine Sciences laboratory at La Parguera using identical species of fish.

The fish used were all collected from the Condado Lagoon except those of Abudefduf saxatilis which were collected near Boca de Cangrejos. The sea water used in these experiments was collected at Boca de Cangrejos, where it was thought to be relatively free of contamination from oil or detergents. The temperature during the experiments ranged from 0% to not more than 15% for the exposure times indicated in the table.

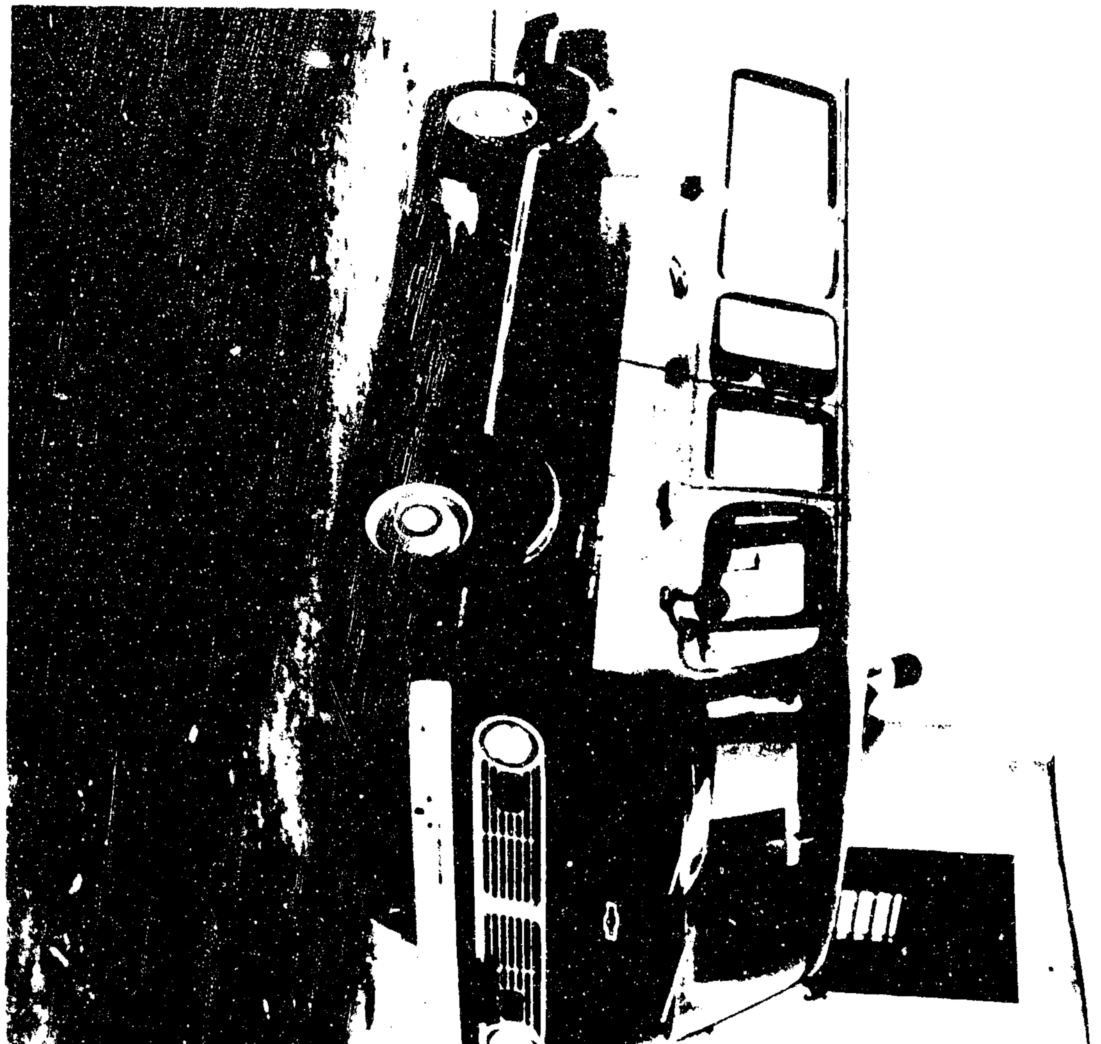
Results

Reference to the table indicated that all the detergents tested expressed toxicity. The toxicity is expressed in terms of percent mortality and percent loss of balance for various concentrations over exposure periods of at least 6, 12 and 18 hours. During the testing, observations were made as to abnormal behavior, change in respiration rate (ventilation), and ability to recover after exposure. Loss of balance is considered when fish no longer can right themselves due to the effect of the detergent. All detergents showed toxic affects on the fish at the lowest concentrations tested. Where death or loss of balance did not occur, there was observed varying degrees of stress apparently caused by the detergents. In some cases there was noted a species-dependent sensitivity.



Scale 1 : 100,000

Figure 1. San Juan Harbor and adjacent areas.



University of Puerto Rico Mayaguez Campus' Mobile Laboratory Unit, Department of Marine Sciences.
OCEAN EAGLE emergency.

Figure 2. Crabs and fish over the oil - impregnated sands at Point Puntilla during the OCEAN EAGLE disaster.

Percent Mortality and Percent Showing Loss of

Balance after Various Exposure Times

Substance Tested	Species Tested	PPM	6hr	12hr	18hr	24hr
Polycomplex A-11	E.a.[1]	100	100(100)	-	-	-
"	A.s.[2]	100	100(100)	-	-	-
"	E.a.	27	57(71)	100(100)	-	-
"	E.a.	10	33(33)	33(33)	33(33)	-
"	A.s.	10	0(0)	33(33)	33(33)	-
"	H.c.[3]	5	0(0)	0(75)	0(75)	-
"	E.a.	5	0(0)	0(0)	0(0)	-
"	A.s.	5	0(0)	0(0)	0(0)	-
"	A.sa[4]	5	0(0)	0(0)	0(0)	-
Janslov-60	A.s.	100	100(100)	-	-	-
"	A.s.	50	100(100)	-	-	-
"	E.a.	27	100(100)	-	-	-
"	A.s.	10	0(0)	0(0)	0(0)	-
Hemco #2	A.s.	100	100(100)	-	-	-
"	E.a.	50	0(30)	60(86)	86(100)	100(100)
"	E.a.	27	100(100)	-	-	-
"	E.s.	10	0(0)	0(0)	0(0)	0(0)
Murati	E.a.	100	70(100)	100(100)	-	-
"	E.a.	50	100(100)	-	-	-
"	E.a.	27	0(0)	14(29)	43(43)	85(85)
"	E.a.	10	8(8)	17(25)	17(42)	25(58)
Product-20215	E.a.	27	29(29)	29(29)	57(57)	57(57)

[1] *Eucinostomus argenteus* - moharra

[2] *Atherinomorus stipes* - silversides

[3] *Harengula clupeola* - herring

[4] *Abudefduf saxatilis* - sergeant major

Substances Tested	Species Tested	PPM	6hr	12hr	18hr	24hr
Mangus	E.a.	27	0(0)	0(0)	0(0)	0(0)
Crude Oil	E.a.	50	0(0)	15(15)	30(30)	30(30)
Ekoperl	E.a.	500	0(10)	10(10)	10(10)	10(10)
"	A.sa	500	0(0)	0(0)	0(0)	0(0)
Pevatone	E.a.	1000	100(100)	-	-	-
"	A.sa	500	0(0)	0(0)	0(0)	0(0)
Minstron	E.a.	1000	100(100)	-	-	-

Conclusions

1. These bioassay tests were, in effect, attempting to determine the toxicity on adult fish after limited periods of exposure to detergents. The adult stage does not represent the most sensitive or critical period of the fishes life cycle. Knowledge is badly needed regarding the long-term effect on all stages of the life cycle before we can intelligently determine the potential damage caused by adding foreign matter to the environment.

In order to eliminate experimental variables caused by keeping animals in captivity in the laboratory, routine bioassays are usually run for a period of 48 to 96 hours. This is thought to be a minimum standard to estimate toxicity and to also provide a better standard for comparison of results.

The results of the above experiments should, therefore, be viewed as expressing the very minimum in terms of toxicity. Thus, these same detergents would show equivalent toxicities at smaller concentrations (ppm) if the tests were run for the standard 48 or 96 hours. Even for the 18 hour test there is seen a high level of toxicity.

2. Detergents usually consist of many substances forming a complex mixture. Different products use differing amounts of solvent (s) as a base for the mixture. Test concentrations are prepared from the concentrated product as it is sold on the market. This is considered to be a 100% solution and test dilutions are prepared accordingly. Because the different products contain widely varying percentages of solvents and because the solvents of each one product may vary considerably in toxicity, it is very difficult to accurately compare any two products. To circumvent this problem, it would be necessary to analyze each component of a given product independently as well as in its various combinations. This approach would be especially difficult because many ingredients of commercial detergents are considered trade secrets.

3. From a practical use standpoint, different detergents should not only be compared in terms of toxicity but also in terms of their relative effectiveness as a dispersant or emulsifier. Caution must be used here also since it is difficult to quantify the effectiveness of a detergent. Also, when a substance (eg. oil) is emulsified or dispersed, the oil itself may display new and different toxic effects on living systems which in an unemulsified state are not as apparent.

4. It is hoped that the above three considerations will be recognized as important ones before the use of detergents is proposed. There is a real need for research in this area so that we may be prepared to cope most effectively with future problems such as that posed by the Ocean Eagle disaster.

Oil Adsorbancy Tests

A number of adsorbents were tested for their initial affinity for the oil, their leaching abilities, and their toxicities to marine forms.

A layer of oil was floated on sea water in enamel trays. Each of a number of adsorbents at hand were placed over the oil layer in separate trays. Tests were conducted with 1) sugar cane bagasse, 2) vermiculite, 3) chemically treated vermiculite, 4) Minstron talc, 5) Ekoperl-33, and 6) Pevatone. After having examined the adsorbant ability of each of these, oil-soaked samples of each were placed on white paper towels and exposed to the sun and weather for over 24 hours.

Results

Adsorbant	Adsorbancy	Leaching
Sugar cane bagasse	None. Competes with oil for surface and spreads it more.	Total leaching. Unable to hold oil.
Vermiculite	None. Competes with oil for surface and spreads it more.	Total leaching. Unable to hold oil.
Chemically treated vermiculite	None. Competes with oil for surface and spreads it more.	Total leaching. Unable to hold oil.
Minstron talc	Excellent. Able to remove thin films of oil. Good for cleaning sands also.	Leaches most of the oil if exposed to the sun.
Ekoperl-33	Excellent. Good for thick layers of oil.	Slight leaching in hot sun.
Pevatone	Fair. Must be forcibly mixed with oil.	Almost no leaching

An account of the offshore use of Ekoperl 33 during the OCEAN EAGLE spill is given by Capt. Trabert M. Felix, Master of the R/V CARITE:

"The first and only really good test of the perlite dust on an oil slick was on Wed. 20 Mar. 68. Accompanied by Liz Hyman, geologist, Obras Públicas, cast off at 1420 hrs. and found an oil slick about 2.5 miles off the Condado Hotel section - directly north. This petroleum slick was approximately 2 miles long and 300 to 500' wide. Its formation was in an East and West direction parallel with the beach and meandered with the tide line. The petroleum was generally, fairly well concentrated, very thick and very heavy viscosity. There was no emulsification although there were small blobs floating independently of the main areas. The petroleum was held in formation on the tide line in the same way floating debris is held. Wind was from ENE at 15 to 18 mph. Sea swell was 4' to 6' and very few white caps. One hundred and twenty-six bags of perlite were dumped directly on the oil as boat proceeded at a speed of 2 to 6 mph. This application was then spread by wave action. The layer of dust in contact with the sea surface was held by the water and oil while the upper layer slid off, continuing to grow larger and larger in area as the

layer because thinner due to this sliding action caused by the waves. This precluded the necessity of running the boat over the dust to mix it as was the case in the calm water inside the bay.

The light colored perlite dust turned a dark brown as it began to pick up the petroleum. After the complete load of 126 sacks had been spread a few passes over the area were made to observe the effects. The perlite apparently cleaned up the area thoroughly where applied. Remaining was an opalescent oil film which it seems that the perlite failed to hold. This was a very thin film of oil. Unfortunately only 126 sacks were aboard. This oil slick area could have been effectively covered with 300 to 350 sacks."

Toxicity Tests on the Adsorbants

Invertebrates

In buckets containing clear sea water, common littoral invertebrates such as chitons, limpets and sea urchins, and under constant aeration, adsorbants were 1) floated on the surface and 2) ground in a mortar and dispersed throughout the water column.

In other tests, sea urchins and limpets were removed from the buckets, rolled in the powdered adsorbants, and returned to the water. No ill effects were observed in any of the tests.

Fishes (see table 1)

Compared to the detergents, all adsorbants tested were considerably less toxic. Since Ekoperl-33 appeared to be the least toxic adsorbant, and also the most effective in adsorbing the oil, it was the product recommended for use.

General Recommendations

No one wishes major oil spills to happen. With increasing tanker traffic and with increasingly larger tankers, there will be more oil spills, however, and future spills will probably be of a greater magnitude. A spill along the south coast of Puerto Rico, near Parguera, could conceivably destroy an area of unique tropical biological interest with its fine reefs and luminescent bays. This would mean irreparable damage to the scientific community and to the general public, as well as the extinction of unusual marine phenomena.

If major oil spills cannot be prevented, at least their harm can be minimized by quick and effective concerted efforts. Some helpful measures might be:

1. Booms. All harbors subject to petroleum traffic should have the capability of quickly deploying several miles of booms. Since wrecks are often caused by adverse sea conditions, a boom effective in high seas and breakers needs to be designed.

2. Off loading. Petrochemical concerns should be required to have barges or some other provision for offloading and transporting oil from a stricken vessel. Tankers should have special emergency accesses into their holds for ease of offloading during an emergency. Such accesses should be positioned in such a way that there is access to the hold regardless of the ship's attitude.

3. Specially trained crews. Just as there are fire-fighting crews and crash crews, there should be oil spill crews available in harbors dealing with oil traffic. These crews should be in charge of boom deployment, offloading, surface pumping, adsorbent deployment and recovery and cleanup. They could be government subsidized and companies with interests in oil traffic should be assigned subscriptions proportional to the volume of oil that they handle.

4. Surface pumps. Pumps capable of removing oil from the surface, and adequate holding tanks, should be mandatory in harbors dealing with oil.

5. Emergency Plan. During the Ocean Eagle disaster, the U.S. Navy, the Coast Guard, the owner of the cargo and the Commonwealth Government all assumed charge of the situation often duplicating efforts and reflecting obvious disorganization. A plan should be designed and authority designated before, not during, an emergency.

6. Adsorbents. Adequate amount of adsorbents, and the capability of their deployment, should be at hand at all times.

Documentary Film

A 16 mm color movie documenta is being edited and may be available at a later date.

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13. ABSTRACT

The report describes the activities of the Department of Marine Sciences, U.P.R. Mayaguez, during the OCEAN EAGLE oil spill. The results of detergent and adsorbant toxicity studies, by bioassay, and adsorbancy tests, are included. A day-by-day report of the disaster and general re[illegible]ns are part of the document.

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